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(19)

(54) PROCESS AND EQUIPMENT FOR COATING A BASE WITH A THERMOPLASTIC MATERIAL

(71) We, CORDOTEX SA, a corporation organised under the laws of Switzerland, of 2 rue de la Paix, Ch-1003 Lausanne, Switzerland, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention is concerned with a process and an equipment for coating a base, especially a strip of paper or paper laminated to metal foil, with a thermoplastic, in which the thermoplastic material is extruded to a thin film which, while it is still warm, is brought into contact with the base and, with simultaneous cooling to a temperature below the softening temperature of the plastic material, is pressed to the base.

In the production, of for example, coating material for packing purposes, it often happens that a layer of thermoplastic material, for example polyethylene, is applied to a base where the thermoplastic material is extruded to a thin film which, while it is still in the molten or semi-molten state, is united with the base which may, for example, consist of a strip of cardboard or a metal foil.

In order to achieve good adhesion between the extruded thermoplastic coating and the base, the base and thermoplastic coating are pressed together between cooled pressure rollers, whereby the thermoplastic layer is brought into good contact with the base and at the same time stabilised by cooling. When carrying out this coating process it often happens that the plastics material adheres to the cooling roll and that the coating material is in this case subjected to a force that is mainly at right angles to the coating surface. This force can easily cause delamination of the material that need not be confined to the boundary zone of the applied plastics layer but the delamination can be localised in the base, for example if this consists of paper or cellular material.

Attempts have been made to avoid the above mentioned difficulty by wetting the cooling roll with water as well as by applying a coating of polytetrafluoroethylene, sold under the Trade Mark "Teflon", to the outer surface of the roll. The best result is achieved with the "Teflon" coated roll but delamination can occur even with such a cooling roll; moreover it has been found that the Teflon material cannot withstand for sufficiently long the mechanical and thermal stresses which arise at the outer surface of the cooling roller.

According to the present invention there is provided a process for the coating of substrate, with a thermoplastic plastics material, in which the thermoplastic material is extruded as a film which, while it is still warm, is brought into contact with the substrate and, with simultaneous cooling to a temperature below the softening temperature of the plastics material, is pressed together with the substrate by passing the substrate and the extruded thermoplastic film through co-operating rolls wherein at least one roll which is in contact with the plastics coat, is moistened on its rolling surface with a liquid that has a surface tension below 73 dyne/cm and a boiling point below 100°C, wherein an uninterrupted liquid layer is applied to the whole contact surface of the roll or rolls with the plastic coat. Suitably the substrate is paper or paper laminated to metal foil.

Further according to the present invention there is provided an apparatus for carrying out the process just described, which comprises an extruder for extruding thermoplastic film onto a substrate; and cooling means for cooling the extruded film comprising a pair of co-operating rolls located downstream of said extruder and capable of pressing substrate passed between them, and moistening means for moistening the surface of the roll or rolls which face the surface of the substrate to which a thermoplastic layer is to be applied which moistening means are arranged so that the liquid is fed continuously to the rolls which are brought into contact with a

coating on a substrate to achieve complete wetting of the roll surface or rolls surfaces.

The invention is described below by the way of example with reference to the enclosed schematic drawings and the photographic representations.

Fig. 1 is a schematic sketch of a coating apparatus.

Fig. 2 is a diagram showing how the adhesion between cooling roller and thermoplastic coating varies according to the critical surface tension of the cooling roller.

Fig. 3 is a photographic enlargement of a cross-section through a coating material which has delaminated.

Fig. 4 is a photographic enlargement of a cross-section through a coating produced in accordance with the invention.

Fig. 5 is a photographic enlargement of the surface layer of the outer plastics coat of a coating material the coating process of which has been carried out in the usual way using a steel cooling roll.

Fig. 6 is a photographic enlargement of the surface layer of an outer plastic layer of a coating material produced in accordance with the invention.

In order to clarify the matter, the concept of critical surface tensions will be discussed in more detail.

It can be said that the critical surface tension of a material is a measure of the tendency to wetting, where the wetting tendency is greater at a lower critical surface tension than at a higher. The physical measure of critical surface tension is expressed in dyne/cm and the size of the critical surface tension can be determined experimentally in several ways well known to those skilled in the art.

It has been found that the critical surface tension for pure metals (measured in a vacuum) is very high, about 1,000—4,000 dyne/cm. Under the conditions ruling in the coating of a base, e.g. paper, with an extruded plastics film it has however been found that the critical surface tension is considerably lower in the case of a polished metal roller, namely about 100 dyne/cm. By wetting a brightly polished cooling roller with water the critical surface tension of the roller can be reduced to the surface tension of water which is about 73 dyne/cm, because the extruded plastics coating does not come into contact with the metal roller but only with the water film covering the roller.

If a polytetrafluoroethylene coat, e.g. the material sold under the Trade Mark "Teflon", is applied to the pressing roller, then the critical surface tension of the roller is reduced to about 17 dyne/cm, i.e. the critical surface tension of the Teflon material.

The plastics material used as a coating usually has a critical surface tension of about 30 dyne/cm (polyethylene has a critical surface tension between 29 and 32 dyne/cm depending on moisture, temperature and other conditions prevailing during the extrusion.)

By adding a surface-tension reducing agent, for example ethyl alcohol, acetic acid or acetone, to water the surface tension can be reduced as shown by the table below, which means that the surface tension can be adjusted as desired by adding the substances mentioned, a fact which—as shown by the description below—is very important.

The apparatus shown schematically in Fig. 1 has a supply roll 1 with a strip 2 of paper or paper coated with aluminium foil, to which a plastics coating is to be applied. The plastics coat 3, which for example may consist of polyethylene, is—while still in the molten state—applied to the strip 2 by means of an extrusion press 4 in which the plastics material is heated to melting and extruded through a longish, cleft-like valve 5 to form a thin film 3. The strip 2 coated with the plastics film 3 is fed in between two cooperating pressing rolls 6 and 7, of which roll 6 is cooled by a cooling agent, preferably water, which is caused to circulate within the roll. By means of a spraying apparatus 8, a liquid in finely divided form is sprayed on to the surface of the roll 6 care being taken that the whole surface of the roll is covered by a liquid layer preferably of uniform thickness. The composition of the said liquid is discussed in detail below and the liquid need not ncessarily be applied by spraying but good results can also be obtained by introducing the liquid in other ways, for example by dipping the roller or by applying with a moistened guiding roller. The finished coating material is indicated in Fig. 1 by 11.

When the plastics coating 3, solidified by cooling, has passed the cooling roll 6, the contact between the surface of the cooling roll and the plastics coat 3 must be interrupted and, because a certain amount of sticking of the plastic coat to the cooling roll always occurs, a tension arises at right angles to the surface of the coating material 11. Since the coating material if it consists, for example, of fibrous material or of fibrous material covered with aluminium foil, has its lowest tensile strength at right angles to the surface of the material (the so-called Z-direction), tears in the material, i.e. so-called cleavage phenomena (delamination), are liable to occur when the coating material has to be pulled off from the cooling roll. In general, cleavage does not occur in the boundary layer between plastics coat and paper, but this cleavage occurs most frequently in the paper layer close to the plastics coat as shown by Fig. 3 which is an enlargement of a cross-section of a delaminated coating material. In Fig. 3 the plastics coat is shown by 12, the fibrous material by 13 and the delaminated zone by 14. In order to avoid delamination it is necessary thus either to use paper material with such a high Z-

strength (tensile strength in the Z-direction) that, in spite of the stresses that arise in the separation of the coating 11 from the cooling roll 6, no delamination occurs, or to ensure that the adhesion between the cooling roll 6 and the coating material 11 is as small as possible. As it is usually difficult to determine the quality and the Z-strength of the paper, the adhesion between the plastic material and the cooling roll 6 must be reduced, which can be done in the way shown by the invention.

In Fig. 2 a diagram is reproduced in which the horizontal axis shows on a linear scale the adhesion between cooling roll and plastics coat and the vertical axis, expressed in dyne/cm, the critical surface tension. In addition, the diagram shows a curve indicated by the Pe which illustrates the adhesion between a polyethylene coating and a cooling roll with cooling roll coatings having various critical surface tensions.

The horizontal axis has no subdivisions in absolute numbers because the adhesion depends on several factors, for example the diameter of the roll and the width of the strip, but the subdivision is in relative numbers 0—10.

As can be seen from Fig. 2, the adhesion is greatest (10) when the cooling roll consists of a dry, polished steel roll with a critical surface tension that should here be 100 dyne/cm. If the roll is wetted with water, then the critical surface tension becomes about 73 dyne/cm and the adhesion is reduced to 7. By the use of a "Teflon" coated cooling roll the critical surface tension can be still further reduced even to about 17 dyne/cm and, as shown by the diagram, the adhesion becomes about 5, which must mean that only a small reduction of the adhesion has occurred although the critical surface tension has been reduced from 73 to 17. By looking at the experimentally produced diagram we see that the smallest possible adhesion, about 3.5, is obtained if the surface of the cooling roll has a critical surface tension of about 30 dyne/cm, i.e. the same critical surface tension as the polyethylene material.

As already mentioned, the cooling roll can be wetted with a liquid the surface tension of which is regulated by, for example, mixing ethyl alcohol, acetic acid or acetone (other agents may also be used) in suitable proportions with water. Since the coating material is to be used for the packing of foodstuffs, ethyl alcohol is the most suitable additive to consider and from the table below it can be seen that an admixture of about 35% by volume ethyl alcohol with water gives a surface tension of about 30 dyne/cm.

Water % by volume	Ethyl alcohol (b.p. 78.5°) % by volume	Critical surface tension
100%	0%	72 dyne/cm
90%	10%	46 dyne/cm
75%	25%	34 dyne/cm
50%	50%	27 dyne/cm
0%	100%	21 dyne/cm

Water % by volume	Acetic acid (b.p. 118.1°C) % by volume	Critical surface tension
90%	10%	55 dyne/cm
70%	30%	44 dyne/cm
50%	50%	38 dyne/cm
0%	100%	26 dyne/cm

Water % by volume	Acetone (b.p. 56.5°C) % by volume	Critical surface tension
90%	10%	49 dyne/cm
75%	25%	38 dyne/cm
50%	59%	27 dyne/cm

If a mixture is fed to the cooling roll 6 in a uniform and uninterrupted layer consisting of 65% by volume of water and 35% by volume of ethyl alcohol, the adhesion between the cooling roll 6 and the plastics coat of the coating material 11 becomes as small as possible (3.5 according to diagram in Fig. 2), and delamination can be prevented. A greatly enlarged cross-section of a coating material that had been treated in accordance with the above instructions, as shown in Fig. 4 where the plastics coat is indicated by 12 and the fibrous layer by 13 and it can be seen from the figure that no delamination has occurred.

A further advantage of the method of the invention is that the plastics coat compared

with the corresponding surface structure of a plastics of coat a coating material produced in the traditional way, has a very uniform surface structure.

Thus in Fig. 5 a greatly enlarged picture of the surface layer of a plastics coat that has been treated with a dry, brightly polished cooling roll is reproduced. As the Figure shows, the surface is full of pits which, when they become deep enough, produce holes in the plastics coat (so-called pin holes). In order to avoid the formation of "pinholes", which is very important if for example the coating material is to be used for the packing of sterilised goods, the thickness of the plastics coat must be great enough to ensure that the depth of the pits formed in the surface coat do not exceed the thickness of the plastics layer. A dimensioning of the plastics coating without having to take into account the pits formed should therefore result in considerable commercial gains.

As shown by Fig. 6, which shows exactly the same material that was treated in accordance with the invention, the surface structure of the plastics coat which has been treated with a cooling roll to which a liquid layer consisting of water and ethyl alcohol has been applied, is considerably more uniform and the pits that can be seen in Fig. 5 hardly occur at all. The reason that the surface structure has been so considerably improved is not entirely clear but everything indicates that the ethyl alcohol, which has a boiling point of 78.5°C, is brought to boiling by the hot plastic coating the surface temperature of which is in general above 100°C when it is brought into contact with the cooling roll. Owing to the fact that the ethyl alcohol is brought to boiling a thin skin of vapour is formed around the cooling roll, which contributes to the uniform surface structure.

As can be seen from the above, several important advantages are obtained by means of the method of treatment of the invention in comparison with the previously known technique because in the first place a reduction of the tension in the Z-direction of the coating material is achieved and hence a diminished risk of delamination and, in the second place, a very uniform surface structure of the plastics coating from the coating material is achieved which frequently means that the thickness of the plastics coat can be reduced because, with the previous dimensioning of the plastics coating the risk of so-called pin-hole formation had to be taken into account.

The wetting liquid gives rise, of course, in comparison with previously known techniques, additional costs but it has proved possible to collect the greater part of the ethyl alcohol for reuse. Hence the costs of the wetting liquid in comparison with the advantages achieved are not important.

WHAT WE CLAIM IS:—

1. A process for the coating of substrate, with a thermoplastic plastics material, in which the thermoplastic material is extruded as a film which, while it is still warm, is brought into contact with the substrate and, with simultaneous cooling to a temperature below the softening temperature of the plastics material, is pressed together with the substrate by passing the substrate and the extruded thermoplastic film through cooperating rolls wherein at least one roll which is in contact with the plastics coat, is moistened on its rolling surface with a liquid that has a surface tension below 73 dyne/cm and a boiling point below 100°C, wherein an uninterrupted liquid layer is applied to the whole contact surface of the roll or rolls with the plastics coat.

2. A process according to Claim 1, wherein substrate is a strip of paper or is paper laminated to a metal foil.

3. A process according to either of the proceeding claims, wherein the said liquid consists of water with an addition of an alcohol.

4. A process according to Claim 3, wherein the alcohol is ethyl alcohol.

5. A process according to Claims 1 and 2, wherein the said liquid consists of water with an addition of acetone or acetic acid.

6. A process according to any of the preceding claims, wherein the liquid is applied to the said roll or rolls by a spraying process.

7. A process according to any of the Claims 1 to 5, wherein the liquid is fed to the said roll or rolls by dipping parts of the roll into a vessel arranged below the roll in which vessel the said liquid is located.

8. A process according to any of Claims 1 to 5, wherein the application of the liquid to the said roll or rolls occurs by means of a coating device that can be brought into contact with the roll or rolls.

9. A process according to any of the preceding claims, wherein the surface tension of the said liquid is adjusted, by admixture of an agent that reduces the surface tension to a value that agrees with the critical surface tension of the thermoplastic material or is only slightly different from it.

10. A process according to any of the preceding claims, wherein the thermoplastic material consists of polyethylene.

11. An apparatus for carrying out a process according to Claim 1, which comprises an extruder for extruding thermoplastic film onto a substrate; and cooling means for cooling the extruded film comprising a pair of cooperating rolls located downstream of said extruder and capable of pressing substrate passed between them, and moistening means for moistening the surface of the roll or rolls which face the surface of the substrate to which a thermoplastic layer is to be applied

which moistening means are arranged so that the liquid is fed continuously to the rolls which are brought into contact with a coating on a substrate to achieve complete wetting of the roll surface or rolls surfaces.

12. An apparatus for carrying out the process of Claim 1, substantially as hereinbefore described with reference to Figures 1, 2, 4 and 6 of the accompanying drawings.

13. A process for coating a substrate according to Claim 1, substantially as hereinbefore described with reference to Figures 1, 2, 4 and 6 of the accompanying drawings.

14. A coated substrate herein obtained by the process of any of Claims 1 to 10 and 13.

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1493511 COMPLETE SPECIFICATION

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Sheet 1

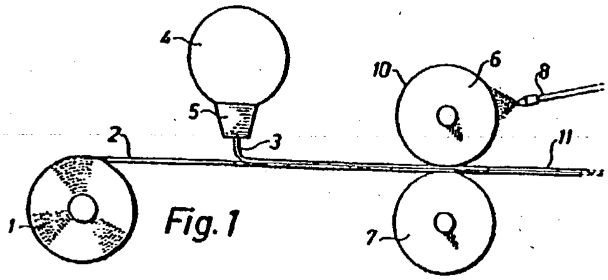
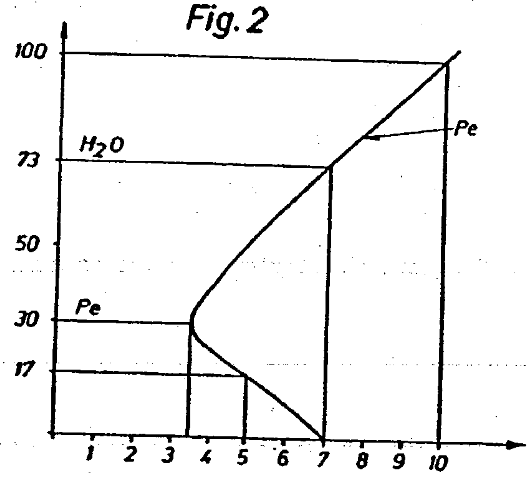


Fig. 1

Fig. 2



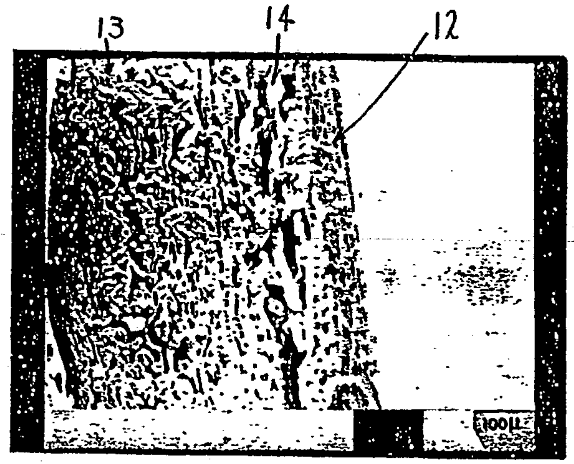


FIG. 3

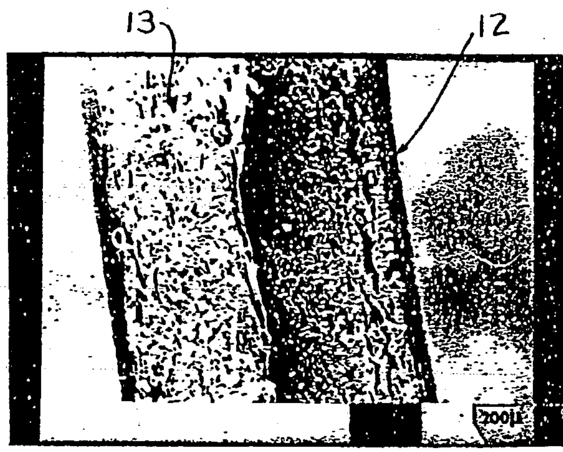


FIG. 4

1493511 COMPLETE SPECIFICATION

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Sheet 3

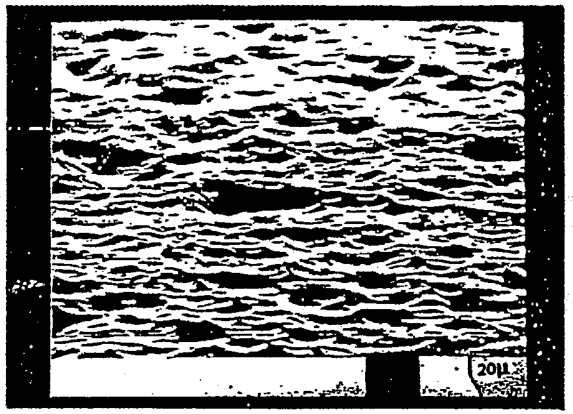

FIG. 5

FIG. 6